Cognitive Styles of Field Dependence/Independence and Weak Central Coherence Theory of Autism

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Abstract

The present paper studied whether the weak central coherence theory of autism and the cognitive style construct of field dependence/independence were equivalent. The Embedded Figures Test (EFT), the Rod-and-Frame Test (RFT) and experiments on visual illusions were administered to fifty autistic and normal children. Data from the EFT revealed no disembedding superiority of autism. The RFT results indicated that the cognitive style of autistic group, similar to normal control, was field independence. No significant groups difference was revealed in susceptibility to geometric illusions. The present findings cannot be explained sufficiently by the central coherence account or the cognitive style construct. Alternative explanations in terms of developmental change and figure-ground perception were given. The experimental manipulation in the present study may not be sensitive in assessing the central coherence account. In addition, the weak central coherence theory is vague and further specification and operationalization of its terms and ideas are necessary to shed light on pecularities of autism.

摘要

Firth and Happe (1994) 提出一套「中央整合」理論（weak central coherence theory）來解釋自閉症兒童比正常兒童在視覺空間感覺能力的測驗及其他有關不需整理整體資料的測驗項目中有較特出的表現。本研究探討「中央整合」理論是否和「認知取向 - 內在/外在因素影響」(Cognitive Style of Field Dependence /Independence; Witkin et al, 1962）有關。本研究選用「嵌圖測驗」（Embedded Figures Tests)、「棒框測驗」(Red-and -Frame Test）及視覺錯覺（visual illusions）實驗，來比較自閉症兒童及正常兒童在測驗中的表現。研究結果顯示自閉症兒童在「嵌圖測驗」及視覺錯覺實驗中的表現與正常兒童沒有顯著分別。而在「棒框測驗」中，兩組兒童皆偏向「受內在因素影響的認知取向」(Field Independence)。 「中央整合」理論及「認知取向」均難對自閉症兒童在研究測驗中的表現作全面的解釋。而他們的表現可能與成長發展（有關自閉症兒童分析視覺組件的能力 [disembedding ability] 和正常兒童在部份與整體認知 [part-whole perception] ）及形象與背景認知【figure-ground perception】有關。此外，「中央整合」理論中提及的一些論點較為含糊，在實驗變項的操作上難有效地作出測試。研究結論提出需多方面發掘和驗正理論中的操作定義，以便對「中央整合」理論及自閉症兒童的表現有較進一步的了解。

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Introduction

Autism, as one of the pervasive developmental disorders, is manifested in impairment in three major areas according to the Diagnostic and Statistical manual of Mental Disorders – Fourth Edition: social interaction, communication as well as repetitive and restricted patterns of behaviors, interests and activities. Although autistic individuals are deficient in social and communicative functions, they are distinctively well in visuo-spatial skills regardless of their levels of ability. These remarkable abilities documented in various research are suggested in relation to the ability to attend to perceptual details (Shah and Frith, 1983; 1993; Brian and Bryson, 1996; Jarrold and Russell, 1997; Jolliffe and Baron-Cohen, 1997).

Weak Central Coherence of Autism

Shah and Frith (1983) found that autistic children demonstrated superior performance on the Embedded Figures Test (EFT) which required the subjects to identify a target figure embedded in complex backgrounds. From the results of past research, autistic subjects demonstrated superior accuracy and were significantly more likely to use "immediate" search strategy compared with that of the normal and mentally retarded non-autistic children. The "immediate" search strategy means " where the subjects seemed to see the target figure right away without any obvious search". The distinctive performance might be related to their high spatial orientation ability which involves the comprehension of the arrangement of elements within a stimulus pattern and special facility in seeing parts in wholes, relevant to the "islets of ability" suggested by Kanner (1943). Some similar findings were replicated by various studies (Shah and Frith, 1993; Brian and Bryson, 1996; Jarrold and Russell, 1997; Jolliffe and Baron-Cohen, 1997). Jolliffe and Baron-Chohen (1997) suggested that the distinctive performance might be related to strength in processing information in non-social domain and unlikely related to intelligence level because the CEFT superiority was found in mentally handicapped autistic children.

Besides the EFT superiority, autistic individuals were found demonstrated remarkable performance in the Block Design and Object Assembly subtests of the Wechsler Intelligence Scale (Shah and Frith, 1993; Bartak, Rutter and Cox, 1975). Shah and Frith (1993) found that the autistic subjects showed excellent performance when they worked from whole design rather than from pre-segmented designs in which the control subjects demonstrated improvement in performance.

Frith (1989) believed that both the strength and weakness of autism arose from a single cause at the cognitive level and proposed that autism is characterized by a specific imbalance in the integration of information at different levels. He suggested that there is a central coherence in human information processing which is a tendency to draw together diverse information to construct higher-level meaning in context. This tendency might be impaired in autism and so, autistic subjects are peculiarly free from contextual constraints. Firth and Happe (1994) suggested a "weak drive for central coherence" in which autism may not show the normal bias towards processing information at a global level but may process information in a more piecemeal and bottom-up manner. The weak central coherence may be viewed as a preference for a particular cognitive style, rather than as a form of deficit or impairment. The theory was able to explain the EFT and Block Design superiority. These tasks require analytic approach which demands attention to more low-level, local information while a more global approach loses this information in the process of integration (Jarrold and Russell, 1997). Although the Block Design and the EFT differ, Shah and Frith (1993) stated that both tasks involved the tendency to resist seeing the whole in favor of seeing the constituent elements. Such local over global preference might be related to difference in cognitive style or the consciously adopted strategy on local preference.

Cognitive Style of Field Dependence/Independence

Witkin and his colleagues (1962) proposed a construct of "field dependence/independence". The construct was referred as perceptual style "to separate an item from the field or context of which it is a part and which therefore exerts a strong influence upon it; to break up a field or configuration". People who are more field independent (articulated or using analytic viewing strategy) are more likely to experience their surroundings analytically, with objects experiences as discrete from their backgrounds. Those who are relatively field dependent (global or holistic viewing strategy) tends to experience his surroundings in a comparatively global fashion, passively conforming to the influence of the prevailing field or context".

According to Witkin and his colleagues (1962), the Embedded Figures Tests (EFT) and the Rod-and-Frame Test (RFT) were used to evaluate individual differences on the field dependence/independence dimension of perceptual functioning. The RFT is designed to evaluate "individual's perception of the position in relation to the upright of an item within a limited visual field". It consists of a square frame, pivoted at the center so that it can be tilted to the left or right. There is a luminous rod moving independently of the frame, pivoted at the same center. The subject is required to adjust the rod to a position perceives as upright. In order to succeed, the subject must extract the rod from the tilted frame through reference to the body position. The EFT does not require orientation but separation of a target item incorporated in the field. Witkin, Goodenough and Karp (1959) found significant correlation among scores for the RFT and EFT of six age groups (age ranging from 8 to 17) in a cross-sectional study. They also found that perceptual development increases with age. A longitudinal study of two age groups (8 to 13 and 10 to 24) found that the field independence increased progressively up to age 17 and became stable.

Visual Illusions

Relationship between cognitive style and geometric illusions

As holistic or analytic viewing strategies reflect tendencies toward or away from the global impression formation, the differences in perceptual style should manifest themselves as differences in illusion magnitude that correlate with measures of field dependence/independence. In fact, susceptibility to geometric illusions was found related to cognitive style of field dependence/independence (Witkin et al, 1962). Illusions, defined by Coren and Gregory (1978), are "the existence of an apparently inexplicable discrepancy between the appearance of the stimulus and its physical reality". In order words, it occurs when a perception diverges from the external world or is incongruent with physical reality. Illusions can be divided into "distortions" and "fictions". Distortions referred to all types of geometric illusions made up of inducing (contextual) and induced (focal) elements. Induced elements refer to stimuli that individuals make judgement of while the inducing elements are referred to stimuli that influence or alter the perception of the induced stimuli. The perception of induced elements is distorted to become shorter or longer (for linear extent), larger or smaller (for size or area), straight or curl (for shape or orientation) and forth. Fictions refer to illusory contours and surfaces that are not physically present.

It was found that the greater the field dependence, the greater the susceptibility (Gardner, 1957). Different research revealed the relationship in various geometric illusions. Karp (1962) reported that the illusion magnitude of Muller-Lyer was related to field dependence measured by the EFT or the Kohs Block Test (in which observers must synthesize a large pattern through the use of small figural units painted on the sides of blocks). Dawson and his colleagues (1973) found significant negative correlation between the field independence measures (the EFT, Kohs Blocks and the RFT) and horizontal-vertical illusions in the Hong Kong

Chinese children. This confirmed the relationship between a more field independent cognitive style and lower illusion susceptibility for the illusion. However, no such relationship was found on Muller-Lyer illusions in the Hong Kong sample. Other studies also established the relationship between field dependence and visual illusions including Sander parallelogram and the Ponzo illusion (Berry, 1966, 1968, 1971; Wober, 1970).

Other approaches to understand visual illusions include the Gestalt theories of perception which stresses the "whole" perception rather than the sum of the parts (Malim, 1994). As a result, visual illusions are to be analyzed on the basis of the whole configuration, rather than any element within. For example, Muller-Lyer illusion is related to observers' attention directed to the overall length of the figure instead of the length of the shaft. As individuals generally exhibit global assessment strategy in information-processing, averaging or assimilation theories as well as confusion theories also arise in explaining illusions. The former refers to an active strategy of the observers to extract the global impression and bias his / her judgement. The latter refers to a more passive process in which the observer had difficulty separating the test (induced or focal) elements from the contextual (or inducing) elements and therefore, confuses the judgement of the induced elements towards the inducing parts.

Weak central coherence and visual illusions on autism

Happe (1996) used visual illusions to examine children with autism, moderate learning difficulties and normal controls. Five geometric illusions (Muller-Lyer illusions, Titichener circles, Ponzo illusion, Poggendorff illusion, and Wundt-Hering illusion) and one illusory contour (Kanisza triangle) were selected. Results revealed that autistic subjects generally made significant more accurate judgements and less succumbed to geometric illusions and illusory triangle. Happe explained the findings in terms of weak central coherence theory in which the autistic subjects fail to integrate the induced and inducing elements and therefore, leading to more accurate judgement of illusions. However, the theory could not explain why there was significant percentage of autistic subjects susceptible to Muller-Lyer illusion.

Summary of previous research & Objectives and hypotheses of present study

To conclude, research on autism revealed that autistic individuals demonstrated superior performance on the Embedded Figures Tests compared that of the control groups. Their distinctive performance was accounted by the weak central coherence theory in which autism failed to process and integrate local information for meaning in context. They are able to perceive the constituent parts and resist the global pattern. However, the EFT was originally used by Witkin et al (1962) to measure cognitive style of field independence. It is the perceptual style to break up a field or configuration. The field dependence/independence cognitive style was found related to visual illusions. As autism were found less susceptible to visual illusions, it remains unclear whether the performance of autism in visual illusions and the embedded figures tasks can be explained by the field dependence/independence construct. The present paper therefore studies the relationship between the cognitive style of autism and their susceptibility to visual illusions at the same time. It aims at exploring whether field dependence/independence cognitive style is equivalent to the weak central coherence theory.

In the present study, the Embedded Figures Test (EFT) and Rod-and-Frame Test (RFT) developed by Witkin et al (1962) was used to assess the cognitive style of individuals. Regarding the EFT, Shah and Frith (1983) did not use the standard presentation but left the target figure present during the search. As consistent superior disembedding performance was reported in various research using both the standard and nonstandard procedures, the standard procedure was selected in the present study in administration of the EFT. For the visual illusions, the illusions used in Happe's study (1996) were selected because these illusions fall into the four major classes of geometric illusions (Coren, Girgus, Erlichman and Hakstian, 1976) which enclose the majority of geometric illusions. The first class is the "shape and direction illusions" which includes distortions in apparent shape, parallelism and colinearity. Examples included Poggendorff and Wundt-Hering illusions and sander parallelogram. The second type is the "size contrast illusions" in which the apparent size of an element appears to be affected by the size of other elements that surround it or form its context. Examples were Titchener circles and Ponzo illusions. The last two types are the "overestimation illusions" and "underestimation illusions". It includes all the apparently longer and shorter versions of the Muller-Lyer illusions, and the horizontal-vertical illusion. Kanizsa triangle does not fall into any classes of the above but as separate category of visual illusions. It was also selected in the present study as an example of illusory contour and to explore whether autism consistently displayed less susceptibility on illusory contours. Illusory contour is defined as "a contour which appears in an area of the visual field that is physically homogeneous" (Watanabe and Oyama, 1988). Kanizsa triangle (Figure 1) is one of the well-known examples in which the observers reported seeing a white triangle in front of an outline inverted triangle, with its corners resting on three squares under white background color. Rock (1987) suggested that the perception of all illusory contours involve figure-ground reversal. Apparently, only the black fragments are figural and the innermost contours are organized as belonging to them and give them shape. When the reversal of figural and background occurs, the contours belong to and give shape to the white triangle and becomes figure. The black fragments no longer look like irregular shapes but like the visible portions of the white triangle.

With reference to the weak central coherence theory, autistic individuals tend to "less capture by wholeness" and process unconnected stimuli efficiently (Shah and Frith, 1983) while normal individuals bias their information-processing towards global and meaningful context. Autistic individuals may be less susceptible to visual illusions compared with the normals. However, if the induced element are highlighted or made distinctive and separated from the contextual stimuli, this may help the normal individuals to bias information-processing towards local, discrete manner. Normal individuals may exhibit less misjudgment on visual illusions. As a result, to further investigate the weak central coherence theory, the visual illusions used in the paper were manipulated in a way to distinct the local (induced) elements by different color, and separation gap between the induced and the contextual elements.

In view of the above research findings, several hypothesis were given as follow:

1. Autistic individuals may show disembedding superiority in the EFT explained by the weak central coherence or field dependence/independence.
2. Autistic and control group may differ in performance of the RFT, which can be explained by the cognitive style of field dependence/independence.
3. The perceptual disembedding ability assessed by the EFT and perception of the upright measured by RFT may be correlated.
4. On the visual illusions, autistic group may be less susceptible to visual illusions compared with the normal individuals.
5. Manipulation of induced elements may reduce susceptibility to visual illusions of the normal individuals.

Method

Participants

Twenty five children (23 male, 2 female), age ranging from 9.3 years to 13.8 years with mean age of 11.7 years (standard deviation of 16.2 months), and diagnosed with autism were recruited through Yaumatei Jockey Club Psychiatric

Center. All met relevant DSM-IV (APA, 1994) diagnostic criteria. They were selected for being of near normal intelligence (IQ may be 85 or above) measured by the Raven's Standard Progressive Matrices (Raven, 1976). They were referred to as high-functioning autistic group.

A comparison group of normal children were matched individually with the participants with autism. They were matched on gender, range of intelligence (difference within ±5 standard scores) and chronological age (difference within ±6 months). Average age of the control group was 11.5 years (age ranged from 9.3 years to 14 years). From Table 1, the two groups did not differ in their chronological age ($t=0.52$, $p=.82$). Mean scores of the Ravens Standard Progressive Matrices between the high-functioning autistic group (96.92) and the normal controls (96.64) also reveal no significant difference ($t= 0.07$, $p=.95$).

Stimuli

The Embedded Figures Test (EFT).

The standard Embedded Figures Test (Witkin et al, 1971) was used. There are two alternative versions (Forms A and B) that do not differ in terms of number of stimuli or difficulty. Form A was chosen and it consists of a set of 12 test cards,

Table 1

Subject Characteristics

	Chronological age in months	Scores of Ravens
Autism	140.63 (16.21)	96.92 (14.22)
Control	138.34 (16.51)	96.64 (14.35)
t-value	0.52	0.07

depicting a different complex design. For each complex design there is a simple shape hidden somewhere within it. In fact, there are only eight different simple shapes because some of these are common to several complex designs.

The Rod-and-Frame Test (RFT).

The rod was 28 cm long surrounded by a 33cm long square frame. The frame and the rod were of 1-cm wide black color strip. Three frame tilts were used (28° clockwise (CW), counterclockwise (CCW) and 0°). There were 3 rod starting positions (28° CW, CCW and 0°). This produced a total of 9 visual displays and each display was presented four times, for a total of 36 trials in counterbalanced presenting order.

Visual Illusions.

Muller-Lyer (classical and Brentano version) (Figures 2 & 3). Illusion magnitude of Muller-Lyer illusion is found affected by the angle and the length of wings (Coren and Girgus, 1978). An angle of 60° with the length of wings between 20% and 35% were found to produce greatest illusion. The Muller-Lyer used in traditional condition was therefore constructed with a shaft length of 150mm long, wing length of 30mm long and at an angle of 60°. The wings and shaft were made at 1mm wide. The wing-out arrowhead was placed horizontally at the top while the wing-in was at the bottom of the computer screen. The distance between the wing-in and –out shaft was 150mm. Another version of Muller-Lyer, the Brentano version, was also used to compare with the classical form to produce maximum illusion magnitude under computer presentation. The Brentano Muller-Lyer was made of one shaft with 2 wing-in arrowheads at the end of the shaft. At the mid-point of the shaft placed a third arrowhead pointing outward. The size of the angle and the length of the shaft and wings were the same as the classical version. The Brentano Muller-Lyer was presented at the central location of the computer monitor.

In the separated condition, the wings and the shaft is separated at 3 mm wide in both the classical and Brentano version. In the color condition, the shaft was highlighted by green color while the rest of the lines remained the same white color in both versions.

Titchener Circles (Figure 4). Illusion magnitude was related to 3 main factors – the number and size of the contextual circles, and the distance between the surrounding (contextual) and central circle (Robinson, 1972). In the traditional condition, the central test circle was 14mm in diameter and was presented with 5 surrounding circles. The diameters of these contextual circles were 22mm. The control condition consisted of the central circle (14mm in diameter) and 5 contextual circles (5 mm in diameter) presented on the left on the computer screen. The distance between the circumference of the central circle and that of the surrounding circles was 3mm. The two standard circles were separated by 70mm. All these configuration variables were set to maximize the illusion magnitude with reference to past research (Clavadetscher, 1991; Girgus, Coren and Agdern, 1972; Pressey, 1977).

In color condition, the central circle was in green color while the contextual circles were white. Configuration variants remained the same as in the traditional condition.

Ponzo illusion (Figure 5). Fisher (1968) found that the critical variable for elicitation of the illusion is the proximity of the test element to adjacent contours. In the traditional condition, the illusion stimulus consisted of a wedge forming a 45° angle that enclosed two horizontally parallel lines. The length of the wedge was 75mm while the horizontal lines were 50mm long. The distance separating the 2 lines was 40mm. The gap between the upper horizontal line and the wedge was

3mm.

In color condition, the 2 horizontal lines were in green color while other illusion stimuli remained the same as that in the traditional condition.

Poggendorff illusion (Figure 6). The Poggendorff illusion is sensitive to variations both in the angle at which the transversal (or obliques) meets the parallels, and in the distance between the parallels (Coren and Girgus, 1978; 1987). In the traditional condition, the illusion was made of two parallels 140mm in length separated by a distance of 30mm. The transversal of 35mm long met the parallel at an angle of 55°.

In separated condition, the obliques and the parallels were separated by a gap of 3mm. In color condition, the obliques were in green color.

Wundt-Hering (Figure 7). Illusion magnitude is related to the angle of intersection with the obliques (Coren and Girgus, 1978). In traditional condition, the illusion consisted of two 150mm long vertical parallels, separated by a distance of 50mm. Nine lines, radiating from a point at the central location of between the vertical parallels, formed an angle of 120°.

In separated condition, the gap between the radiating lines and the verticals was 3mm. In color condition, the 2 verticals were highlighted in green.

Kanizsa triangle (Figure 1). The standard Kanizsa triangle figure was presented at the center of the computer monitor. The incomplete white circular elements at the corners of this figure were 19mm in diameter and the edges of the 60° angels forming parts of an equilateral triangle. The sides of the black partially enclosed triangle and those of the outline triangle were 63mm and 65mm long respectively. The Kanizsa triangle was presented once in the traditional condition.

Procedure

Each subjects was administered the EFT, the RFT and the visual illusions experiments on a counterbalanced order in separate rooms.

EFT

All subjects were tested individually in a quiet room in the University. The standard procedures were followed: the designs were presented in a fixed order to guard against demotivating subjects, since the items become progressively more difficult. Practice item was given first before the test items. A stylus was given to trace the outline of the target shape in each design. Response time (the time taken to correctly locate/trace out the embedded figure) was measured by a stopwatch. In the practice trial, the experimenter showed the practice design for 15 seconds. The design was then turned over to show a simple shape on the back for 10 seconds. The experimenter re-exposed the design by turning over the card and started recording the response time immediately. In the test trials, the experimenter presented each test design for 15 seconds. The procedure was similar to that of the practice trial but during test trials, positive comments might be given to the subjects as encouragement.

Two scores were recorded. One was the response time, which was the time, taken to correctly locate/trace out the embedded figure. Another one was the accuracy score, which was the number of correct solutions within the time allowed.

RFT

Subjects were individually tested and seated at a distance of 64 cm from the stimulus and their heads were supported by a headstand. According to the original instructions, the test could be presented as a "game" when children were used as subjects (Witkin, et al, 1962). The procedure was made concrete by actual demonstrations and 5 practice trials were given. The concept "vertical" is carefully defined in terms of concrete and specific reference criteria such as the flagpole outside the building. The subjects were instructed to direct the experimenter in aligning the rod with the gravitational vertical while the frame remained unchanged. No time limit was given. The order of the 36 trials was counterbalanced.

The score for the 36 trials was the mean absolute error in degrees from the true upright. Subjects' RFT score were determined by calculating the mean of error in degrees (Morell, 1976). Subjects were considered field dependent if their mean error was above 4° of error (Pizzamiglio and Zoccolotti, 1981).

Visual Illusions

Visual illusion stimuli were presented by an IBM 586 compatible computer with a standard 17-inch monitor and screen resolution in all experiments was 68 pixels/ inch. The stimulus lines (1 pixel wide) were white on a dark background and were viewed with normal fluorescent room lighting. Subjects were instructed to sit at a distance of 600mm from the computer monitor and their heads stabilized by a headrest. They looked at the monitor with binocular vision under no time limit. Presentation of the illusory figures of the three conditions was counterbalanced in order. Subjects responded to experimenter's instructions by pressing two assigned keys on a button box. Measurements of the illusion magnitude in terms of the net change in millimeters, the illusion magnitude and the corresponding time in milliseconds of each key-pressing were recorded by the computer. Cantonese instructions on visual illusions were given in appendix I.

Muller-Lyer (Brentano version). The task was to adjust the central arrowhead until it appeared to bisect the line. The subjects responded by pressing one of two keys and each response moved the central arrowhead one pixel left or right. Illusory magnitude was measured as the change in distance of the mid-point arrowhead in mm from the original central location.

Muller-Lyer (classical version). Subjects were instructed to judge whether the two shaft appeared longer, shorter or equal in length. Subjects indicated their judgement by pressing 2 keys to make the shaft of inward-fin Muller-Lyer appeared as the same as the outward-fin Muller-Lyer. They were instructed not to press any keys if they perceived the two Muller-Lyer equal in shaft length. Illusion magnitude was recorded as the change in length of the lower shaft from its original size of 150mm long in mm.

Titchener Circles. Subjects' task was to adjust the standard circle on the left of the screen to appear equal to the central circle on the right if they perceived the 2 inner circles were in different sizes. Illusion magnitude was measured as the net change in diameter of the left inner circle from the original size of 14mm.

Ponzo illusion. Subjects' task was to adjust the lower horizontal line to appear equal to the upper one if they perceived the 2 lines unequal in length. Illusion magnitude was recorded as the net change in length of the lower horizontal line from the original 50mm long in mm.

Poggendorff illusion. Subjects were instructed to move the left oblique segment up or down along the left vertical line in order to align it with the right oblique segment. Illusory magnitude was measured as the distance of the left oblique segment from the original position in mm.

Wundt-Hering. Subjects adjusted the 2 vertical lines outward from or inward towards the center to indicate that the 2 vertical lines perceived to be up-right or curved. Illusory magnitude was recorded as the net horizontal distance between the 2 verticals in mm from the original 50mm long.

Kanizsa triangle. Subjects were asked what figures they could see at the center of the illusion. If their answers were "triangles", they were instructed to outline the shape of the triangle by using a ruler over the monitor. If the illusory triangle could not be perceived, they were instructed to press two keys either to lighten or darken the color strength of the black background until they could just perceive the central illusory triangle. The magnitude of the gradient ranged from 0 (black like the background) to 250 (white) units was recorded.

Results

EFT.

The mean response time and mean accuracy score of EFT for each of the group is shown in Table 2. The two groups did not differ in terms of accuracy ($F_{2, 48} = .13$, $p=.18$) and response time ($F_{2, 48} = .34$, $p=.31$). As a result, the hypothesis in which autism may be characterized by disembedding superiority is not supported. Generally, the disembedding speed and accuracy in picking the target figures was

Table 2

Mean (SD) Response time and Accuracy scores of Embedded Figures Test

	Response Time (seconds)	Accuracy score (total is 12)
Autism	78.02 (41.23)	8.64 (0.59)
Control	66.06 (40.92)	9.84 (3.20)

found mildly correlated (Table 3). In autistic group, a negative correlation was found in which the longer the time they spent on disembedding, the lower the accuracy on the tasks. However, no such relationship was revealed in the normal group. The disembedding speed and accuracy was unrelated.

RFT.

The autistic group and the control group differed significantly in terms of the mean degrees of error ($F_{5,45} = 9.29$, p=.01) as shown in Table 4. With reference to Pizzamiglio and Zoccolotti's (1981) criteria, both groups of subjects performed in a relatively field independent manner. However, the autistic group made more errors from the true upright. They were relatively more field dependent when compared with the normal controls by their mean absolute degrees of error.

Correlation between EFT and RFT

Our subjects' performance on the EFT and the RFT were significantly correlated as revealed in Table 5. Among the normal controls, there was a strong positive relationship between the disembedding ability and perceptual orientation. The central coherence and the cognitive style of perception may be of related construct. However, no such relationship was found in our autistic group. This

Table 3

Correlation between Response time and Accuracy scores of Embedded Figures Test

	Pearson r
All Subjects	.31*
Autism	-.56**
Control	.04

Note. *p< .05

**p<.005

Table 4

Mean (SD) Degrees of Error of the Rod-and-Frame Test.

	Degrees of error
Autism	3.15 (2.33)
Control	1.25 (1.77)

Table 5.

Relationship between the Embedded Figures Test and the Rod-and-Frame Test

	EFT (seconds) & RFT Pearson r
All	.52***
Autism	.32
Control	.76***

Note. ** p<.05.

***p<.005

suggests that the disembedding ability and the cognitive style of the autistic individuals fall into two different constructs.

Visual Illusions

Geometric illusions.

Illusion magnitude more than 3 standard deviation of each group were processed as outliners and not analyzed. Two way MANOVA (repeated measure) analyses with a within-subject variable, conditions of geometric illusions (traditional vs separated vs color) and a between-subject variable, type of group (autism vs control) on geometric illusions were run.

Analysis of repeated measures revealed that there was no main effect for conditions in the following types of illusions (Muller-Lyer classical version: $F_{2,48}$=1.12, p=.33; Muller-Lyer Brentano version: $F_{1,49}$=1.12, p=.30; Titchener circles: $F_{1,49}$=3.54, p=.07; Ponzo illusion: $F_{1,49}$=0.11, p=.74; Wundt-Hering illusion: $F_{2,48}$=1.43, p=.25; Poggendorff illusion: $F_{2,48}$=.68, p=.51). Manipulation of variables with reference to the weak central coherence theory could not produce the expected effects in which normal individuals might have less illusion in separated or color conditions. In addition, there was no main effect for groups tested (Muller-Lyer classical version: $F_{1,49}$=2.63, p=.11; Muller-Lyer Brentano version: $F_{1, 49}$=.77, p=.38; Titchener circles: $F_{1,49}$=.44, p=.51; Ponzo illusion: $F_{1,49}$=2.3, p=.13; Wundt-Hering illusion: $F_{1,49}$=.83, p=.37; Poggendorff illusion: $F_{1,49}$=2.48, p=.12).

However, significant interaction effects of group and conditions of illusions were revealed in Poggendorff illusion ($F_{2, 48}$=5.00, p=.009) as shown in Table 6. The overall interaction effect (groups x conditions) was attributed to comparison involving stimuli (separated vs color condition) and group ($F_{1, 49}$=8.22, p=.006). By using the independent-sample T-test to compare group difference on specific condition, autistic group and the controls did not differ in mean illusion magnitude in traditional ($t_{3, 47}$=1.25, p=.22) and color condition ($t_{3, 47}$=0.09, p=.93). However, under the separated condition, autistic group had significantly greater illusion than the normal controls ($t_{3, 47}$=2.44, p=.02).

Significant interaction effects of group and conditions of illusions also reported in the Wundt-Hering illusion ($F_{2, 48}$=4.90, p=.01) as shown in Table 7. The overall interaction effect (groups x conditions) was attributed to comparison involving stimuli (traditional vs color condition) and group ($F_{1, 49}$=10.03, p=.002), and stimuli (separated vs color condition) and group ($F_{1,49}$=7.58, p=.015). By using the

Table 6

Mean Illusion Magnitude (SD) of the Poggendorff Illusion in mm.

	Traditional Condition	Separated Condition	Color Condition
Autism	11.33 (13.73)	13.45 (15.77)	8.21 (9.30)
Control	7.42 (7.32)	5.04 (6.79)	7.99 (8.20)

Table 7

Mean Illusion Magnitude (SD) of the Wundt-Hering Illusion in mm.

	Traditional Condition	Separated Condition	Color Condition
Autism	0.57 (0.21)	0.34 (0.21)	0.20 (0.20)
Control	0.41 (0.20)	0.30 (0.20)	0.98 (0.20)

independent-sample T-test, significant group differences revealed in color condition ($t_{3,47}$=3.01, p=.004) but not in traditional ($t_{3,47}$=0.84, p=.41) and separated conditions ($t_{4,46}$=0.54, p=.59).

Illusory Contour.

Results of Kanizsa triangle (Table 8) revealed that autistic group is less susceptible to illusory contours. They need more external cues (lighter color) than the normal controls to perceive the illusory triangle ($t_{4,46}$=.2.67, p=.01). From Table 9, they made more adjustment on each key-pressing in controlling the color strength as significant differences were found in increasing color strength ($t_{4,46}$=3.10, p=.005) and decreasing color strength ($t_{4,46}$=2.38, p=.02). They also pressed significantly longer on each key-pressing to increase color strength ($t_{4,46}$=2.83,p=.009) and to decrease color strength ($t_{3,47}$=2.51, p=.017). The key-pressing manner of autism showed that they had greater difficulty in seeing the illusory triangle.

Relationship between EFT, RFT and Visual Illusions

To explore whether the performances on visual illusions were related to the performances of the EFT or RFT, correlation analyses were administered.

Table 8

Mean Illusion Magnitude (SD) of the Kanizsa Triangle

	Color strength **
Autism	62.46 (86.92)
Control	12.17 (30.63)

Note ** $p<.01$

Table 9.

Mean Color Strength (SD) of each key-pressing of the Kanizsa Triangle

	Increase of color strength (lighter color) per key-pressing ***	Decrease of color strength (darker color) per key-pressing *	Timing (msec) on increasing strength (lighter color) each key-pressing ****	Timing (msec) on decreasing strength (darker color) each key-pressing *
Autism	45.42	38.20	1702.92	1655.16
	(60.08)	(54.75)	(2248.43)	(2186.28)
Control	7.00	9.42	340.67	450.88
	(14.84)	(22.63)	(711.88)	(966.91)

Note * $p<.05$

*** $p<.005$

**** $p<.001$

Relationship between EFT and Visual illusions

When the mean illusion magnitude of the three conditions (traditional, color and separated conditions) of visual illusions was used, no significant correlation was revealed between the illusion magnitude and the performances of EFT of all our subjects (Table 10).

When correlation was administered on each group of subjects, significant positive correlation was found between the EFT and Muller-Lyer illusion (classical version) in the autistic group but not in control group (Table 10). In autistic subjects, the poorer the disembedding ability in terms of longer disembedding time, the more illusion magnitude revealed in perceiving the Muller-Lyer (classical version) illusion. For the normal group, the performances on visual illusions was found generally not related to the performance on EFT.

When the correlation was further explored between the EFT and specific geometric illusion on each condition for all our subjects, no significant correlation was found generally as shown in Table 11.

Table 10.

Correlation Coefficients (r) between EFT and Visual Illusions(mean illusion magnitude of all conditions)

	All Subjects	Autism	Normal
Muller-Lyer (classical version)	.22	.44*	.04
Muller-Lyer (Brentano version)	.05	.11	-.04
Titchener Circles	.25	.16	.31
Ponzo illusion	.05	.10	.08
Poggendorff illusion	.06	.11	-.12
Wundt-Hering	.26	.17	.35
Kanizsa triangle	-.01	-.03	-.22

Note * $p<.05$

Table 11.

Correlation Coefficients (r) between EFT and Geometric Illusions of each Conditions

	All Subjects	Autism	Normal
Traditional condition:			
Muller-Lyer (classical version)	.21	.50*	-.19
Muller-Lyer (Brentano version)	-.09	-.08	-.11
Titchener Circles	.19	.09	.26
Ponzo illusion	.05	.20	-.01
Poggendorff illusion	.10	.12	.00
Wundt-Hering	.13	.08	.20
Separated condition:			
Muller-Lyer (Brentano version)	.20	.30	.02
Poggendorff illusion	-.00	.05	-.32
Wundt-Hering	.23	.06	.64**
Color condition:			
Muller-Lyer (classical version)	.24	.36	.10
Muller-Lyer (Brentano version)	.00	-.00	-.03
Titchener Circles	.26	.20	.31
Ponzo illusion	.09	.18	.15
Poggendorff illusion	.07	.17	-.03
Wundt-Hering	.19	-.07	.41*

Note * p<.05

** p<.01

In autistic group, performance on the EFT and the illusion magnitude of Muller-Lyer (classical version) in traditional condition was found significantly correlated. The positive relationship revealed that the poorer the EFT (greater the disembedding speed), the more susceptible to the illusion. In the normal control, significant positive correlation was found on the Wundt-Hering illusion in separated condition and in color condition. That is, the slower the disembedding speed in the EFT, the greater the illusion magnitude.

Relationship between Cognitive Style and Visual Illusions

When exploring the correlation between the performance on RFT and mean magnitude of visual illusions of all subjects, significant positive correlation was found between the RFT and the Muller-Lyer (classical version). That is, the greater the error in RFT, the more susceptible to Muller-Lyer (classical version) illusion (Table 12).

As the relationship was further explored, both the autistic and the normal group did not reveal significant correlation on the Muller-Lyer (classical version) illusion. In the autistic group, performance on the RFT was found not significantly correlated with any visual illusions. In the control group, significant positive correlation was found with Wundt-Hering illusion (Table 12). The more errors in RFT, the greater the illusion magnitude in perceiving Wundt-Hering illusion of the normal control.

As the relationship was explored between the RFT performances and specific geometric illusions of each conditions of all subjects (Table 13), significant positive correlation was found between the RFT performance and the Wundt-Hering illusion in separated condition and Muller-Lyer illusion (classical version) in color condition. That is, the greater the degrees of error in the RFT, the greater the illusion magnitude. On the other hand, significant negative correlation revealed on the Ponzo illusion in traditional condition. That is, the fewer the error in the RFT, the more susceptible to Ponzo illusion in traditional condition.

In the autistic group, significant negative correlation was found between the RFT performance and the Ponzo illusion in the traditional condition and color condition. In the control group, significant positive correlation was revealed between the RFT performance and the Wundt-Hering illusion in separated condition and the color condition.

Table 12.

Correlation Coefficients (r) between RFT and Visual Illusions (mean illusion magnitude of all conditions)

	All Subjects	Autism	Normal
Muller-Lyer (classical version)	.33*	.35	.18
Muller-Lyer (Brentano version)	-.10	-.29	.09
Titchener Circles	.05	-.28	.37
Ponzo illusion	-.25	-.38	.05
Poggendorff illusion	.15	.18	-.14
Wundt-Hering	.23	.14	.43*
Kanizsa triangle	-.01	-.17	-.20

Note * $p<.05$

Table 13.

Correlation Coefficients (r) between RFT and Geometric Illusions of each Conditions

	All Subjects	Autism	Normal
Traditional condition:			
Muller-Lyer (classical version)	.28	.39	-.06
Muller-Lyer (Brentano version)	-.19	-.38	.04
Titchener Circles	.11	-.11	.31
Ponzo illusion	-.34*	-.44*	-.14
Poggendorff illusion	.12	.17	-.18
Wundt-Hering	-.05	-.20	.05
Separated condition:			
Muller-Lyer (Brentano version)	-.05	-.25	.21
Poggendorff illusion	.18	.14	-.11
Wundt-Hering	.38**	.26	.76**
Color condition:			
Muller-Lyer (classical version)	.36*	.30	.38
Muller-Lyer (Brentano version)	.04	.02	.01
Titchener Circles	-.03	-.39	.38
Ponzo illusion	-.21	-.45*	.23
Poggendorff illusion	.07	.18	.09
Wundt-Hering	.01	-.33	.48*

Note * $p<.05$

** $p<.01$

Percentage of Subjects Succumbed/Not succumbed to Geometric Illusions

The number of subjects (autism vs normal) succumbed to every illusion of each condition was calculated and compared by chi-square with results shown in Table 14. Pearon chi-square statistic revealed that group of subjects was related to the susceptibility to Kanizsa triangle (χ^2=5.69, p<.05), Wundt-Hering illusion in color condition (χ^2=3.95, p<.05) and Ponzo illusion in color condition (χ^2=5.20, p<.05). The percentage figures showed that there was a tendency for relatively more normal controls succumbed to the illusory triangle, but more autistic subjects succumbed to Wundt-Hering and Ponzo illusions in color condition.

Discussion

Discrepancy is found between our research finding and previous research on the disembedding ability of autism. Our autistic group did not reveal any disembedding superiority in terms of speed and accuracy. Such discrepancy may be explained by perceptual development. Brain and Bryson (1996) suggested that the EFT performance improved with chronological age, regardless of verbal and nonverbal abilities. This is consistent with the developmental research, which shows a continuous increase in disembedding speed between approximately 8 and 15 years

Table 14.

Percentage of subjects (Autism vs Normal) Susceptible to Geometric Illusions of each Conditions

	Autism		Normal		p-value
	Nil(%)	Yes(%)	Nil(%)	Yes(%)	
Traditional condition:					
Muller-Lyer (classical version)	4	96	12	88	.30
Muller-Lyer (Brentano version)	24	76	28	72	.75
Titchener Circles	12	88	24	76	.27
Ponzo illusion	48	52	28	72	.15
Poggendorff illusion	36	64	28	72	.54
Wundt-Hering	64	36	56	44	.56
Kanizsa Triangle	54	56	21	79	.02*
Separated condition:					
Muller-Lyer (Brentano version)	28	72	20	80	.51
Poggendorff illusion	20	80	40	60	.12
Wundt-Hering	68	32	64	36	.77
Color condition:					
Muller-Lyer (classical version)	8	92	20	80	.22
Muller-Lyer (Brentano version)	20	80	24	76	.73
Titchener Circles	20	80	28	72	.51
Ponzo illusion	60	40	28	72	.02*
Poggendorff illusion	40	60	20	80	.12
Wundt-Hering	68	32	40	60	.05*

Nil = % of subjects not succumbed to illusion

Yes = % of subjects succumbed to illusions

p-value: * $p<.05$

(Witkin et al, 1971). In our study, the chronological age of our subjects is comparatively younger than that of other research (Table 15). This raised several possibilities of explanation. One possibility is that if autism did have a distinctive spatial disembedding ability, the younger autistic children may not have developed this ability sufficiently. They, therefore, did not excel in tasks required disembedding skills.

Another possible explanation concerned the development of part-whole perception of ordinary children. Whiteside, Elkind and Golbeck (1976) found that normal children aged between 6 and 8 tended to perceive aspects of both parts and whole of the figure but in a sequential, non-hierarchically integrated fashion. As children grows older, their information processing change from focusing on parts to focusing on whole. The normal individuals may then be dominated by whole perception. The older normal control, therefore, displayed weaker ability to identify hidden figures in the disembedding tasks in the past research. Such developmental change may account for the differences in disembedding abilities between adults and children in the past studies.

The fixation pattern of autism may also account for the discrepancy. The EFT

Table 15.

Mean Chronological Age (SD) in years of Autistic Subjects among different research.

	Our Subjects	Shah and Frith (1983)	Brian and Bryson (1996)	Jolliffe and Baron-Cohen (1997)
Autism	11.7 (1.35)	13.3 (3.53)	19.54 (5.64)	30.71 (7.84)
Control	11.5 (1.38)	9.3 (1.36)	11.81 (3.60)	30 (9.12)

aims to examine visual search and tracing of embedded figures in the background (Spreen and Strauss, 1998). Successful performance requires perceptual shifting and focusing (Talland, 1965), and perceptual flexibility (Beard, 1965). From the performance on eye-movement study of our autistic subjects (Chui, 1999), autism had significantly more diffuse eye movements and difficulty sustaining their fixations within target area. Their ability to shift attention from non-target figures is therefore affected. In addition, even they may identify parts of the target figure, they may experience difficulty sustaining their attention on the parts found and continuously focusing on the necessary information, thus resulting in comparatively weaker disembedding performance and insignificant group difference in the present study.

The tool used in the present study to assess the disembedding ability was an adult's version. It is assumed to be more difficulty than the children's version used in the past research. The difficulty level may hamper superior performance in identifying hidden figures and thus, produces a floor effect to performance. Nevertheless, judging from the absolute figures of the disembedding results, there was a tendency for normal controls to show better performance in terms of speed and accuracy. The adult version being used in the study therefore did not result in methodological problem to account for the discrepancy found.

From the results of geometric illusions, no significant main effects for conditions of different classes of illusions were found. That is, the manipulation of variables to separate the inducing and induced elements in illusions did not result in less misjudgment of normal controls in geometric illusions. These manipulations, by using color and gap to highlight and separate the induced elements, were based upon the weak central coherence theory in which autism showed a tendency to process and be biased by local information and ignore the contextual stimuli. The manipulation was initially expected to induce less illusion on the normal control because it became easier for them to separate and focus on the induced stimuli and less influenced by the contextual elements. As significant findings on lessened illusion magnitude was not reported in normal control group, it raised doubt whether the present experimental manipulation is valid in testing the central coherence account. There may be other ways of manipulation in separating the induced stimuli or making the induced elements distinctive from the contextual elements, which may result in less susceptibility to illusions of normal control or producing group differences on illusion magnitude of visual illusions.

Regarding the methodological issues in the present experiment of visual illusions, our illusory stimuli were presented with zero illusory magnitude (that is, the focal elements were arranged in position or size that congruent with the testing elements and such that no illusory magnitude existed in reality) although the configuration of stimuli were constructed to maximize the illusion magnitude. The zero illusory presentation may act as the confounding variable to account for the results obtained. Further exploration of autistic performance on visual illusions with stimuli and presentation constructed with a random amount of illusory magnitude is suggested.

On the other hand, regarding the past studies concerning the weak central coherence account, the theory is found not only applicable to explain the performance of autistic children on tasks required visuo-spatial analysis and synthesis and spatial segmentation (Brian and Bryson, 1996; Jolliffe and Baron-Cohen, 1997; Shah and Frith, 1983, 1993), but also for autistic performance on tasks demanded counting of dots (Jarrold and Russell, 1997) and integration of linguistic materials (Happe, 1997). The theoretical constructs of the weak central coherence theory were highly abstract and not well operationalized. Problems may arise when translating the theoretical terms into experimental terms.

The autistic group was found significantly less susceptible to Wundt-Hering illusion in color condition than normal control. Further exploration revealed that the performance of the control group was related to their performance on the EFT and the RFT. However, the less susceptibility of Wundt-Hering illusion under color condition of autism cannot be explained with reference to their performance on the EFT and the RFT. From the correlation analysis, significant relationship was revealed between the EFT or the RFT and different geometric illusions under different conditions. Both positive and negative correlation was found among various geometric illusions, under different conditions and in different groups. In addition, the chi-square statistic showed that there appeared relatively more normals succumbed to Kanizsa triangle but higher percentage of autistic subjects succumbed to Wundt-Hering and Ponzo illusions in color conditions. The data were so diverse to be explained comprehensibly by the EFT, the RFT or both. The present study cannot provide sufficient information to shed light on these data and it remains unclear what and how other explanations can account for the data obtained. Future review on autistic performance on Wundt-Hering illusion, Poggendorff illusion, Ponzo illusion and Muller-Lyer illusion (in particular the classical version) and explanations may therefore be necessary.

Data from the RFT showed that both the autistic and control groups are field independent. Pizzamiglio and Zoccolotti's (1981) criterion of field independent style, however, may appear less flexible because the criterion mainly applies for adults. The criterion for children, for all ages and for different cultures await for further exploration. Judging from absolute figures of mean degree of errors, difference in cognitive style is revealed. Despite the tendency of our autistic subjects to show field independence, the cognitive style construct cannot account for, or at least inadequate to explain, the contradictory results of the geometric illusions and illusory contours. A common finding is revealed both in Happe's (1996) and our research on Kanizsa triangle in which autistic individuals consistently displayed difficulty in perception of illusory contour. However, the susceptibility to geometric illusions of our autistic subjects was contrast with the results of Happe (1996). Comparing the perception of geometric illusions and illusory contours, the latter require fixation of all stimuli rather than on specific focal or contextual elements, and sustaining their fixation and attention for a short period of time. Autism was found relatively weak in these two requirement (Chui, 1999) and thus, resulting in less susceptibility to the illusory contours. In fact, these weaknesses were also reflected in their relatively longer key-pressing and more adjustment on color strength in order to perceive the illusory contours.

On the other hand, the perception of illusory contours and identifying a target figure from the embedding context involves figure-ground perception. Autism may be weak in figure-ground reversal which is crucial in the formation of illusory contours. As there is a lack of research on the figure-ground perception of autism, it is suggested that autism may has deficient in discriminating or defining elements as “figure” and which as “ground”. They may define differently from the normals or have problems in forming gestalt laws of organization - proximity, similarity, closure and continuity. Autistic individuals may have difficulty in achieving laws of closure and continuity, which are important in perceiving Kanizsa triangle. If autism has problems operating the laws, it will not be unlikely for them to have problems in relatively higher level figure-ground perception and reversal in the disembedding tasks.

To conclude, the present paper aimed to explore whether the cognitive style construct of field dependence/independence was equivalent to the weak central coherence theory in explaining the disembedding ability and susceptibility to visual illusions of autism. From our data, performances by autism on disembedding task and visual illusions were comparable to that of normal controls. Performance on these tasks could not be explained comprehensibly by the weak central coherence nor the cognitive style construct of field dependence/independence. In fact, their performances may be affected by developmental change on disembedding ability, part-whole perception as well as the figure-ground perception. Besides, the weak central coherence theory of autism may be highly abstract as it is found applicable to wide range of tasks or performances of autism. Operationalization of the terms of the theory may be necessary. In addition, further exploration on figure-ground perception of autism is suggested to shed light on their visual-spatial abilities.

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